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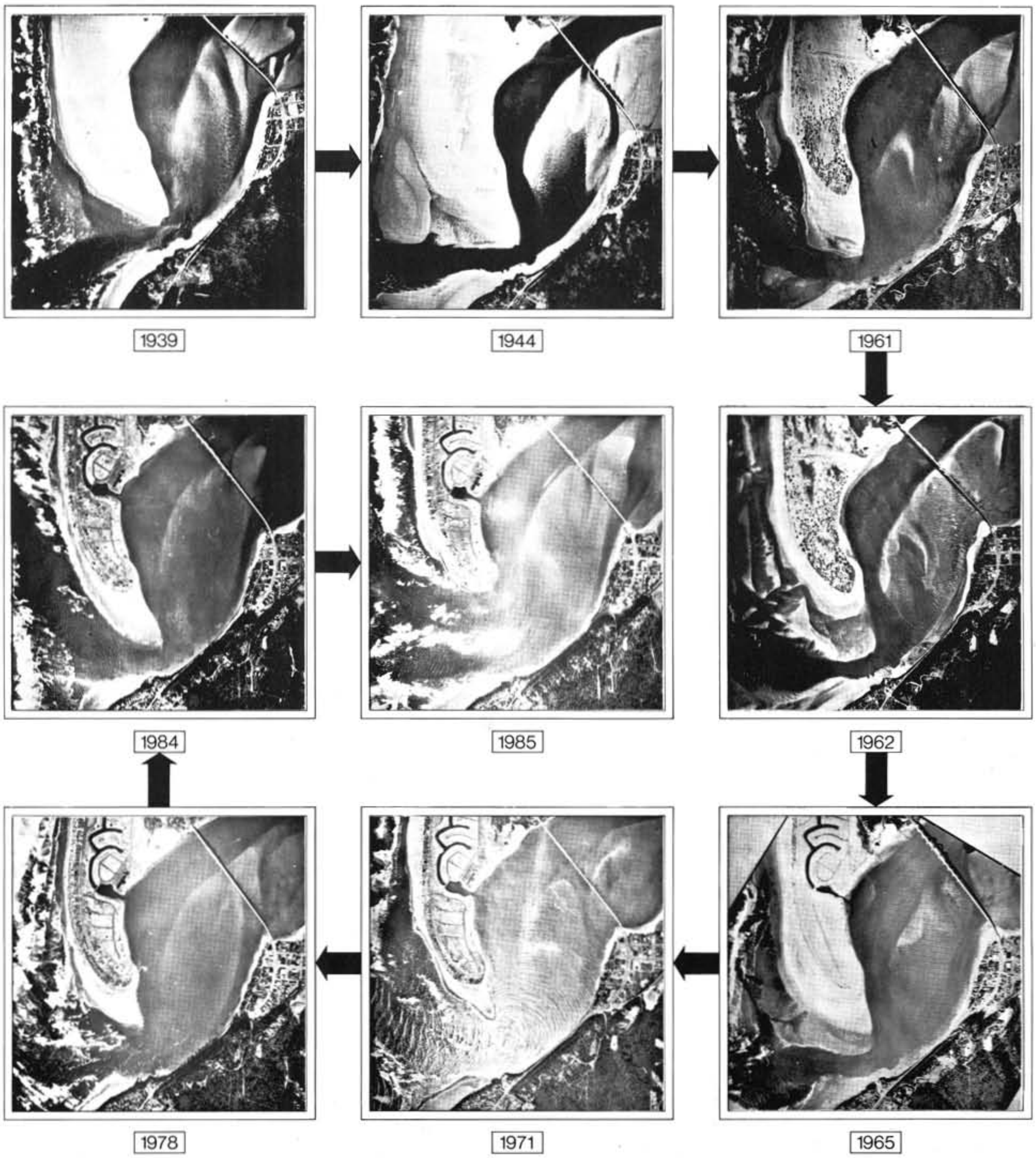

THIS MONTH:
Erosional changes at Alsea Spit, Waldport

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Information for contributors

Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted, typed double-spaced throughout (including references) and on one side of the paper only. Graphic illustrations should be camera-ready; photographs should be black-and-white glossies. All figures should be clearly marked, and all figure captions should be typed together on a separate sheet of paper.

The style to be followed is generally that of U.S. Geological Survey publications (see the USGS manual *Suggestions to Authors,* 6th ed., 1978). The bibliography should be limited to "References Cited." Authors are responsible for the accuracy of the bibligraphic references. Names of reviewers should be included in the "Acknowledgments."

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, news, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI.

COVER PHOTO

Selective chronological photo record of changes at Alsea Spit, Waldport, Oregon, from 1939 to 1985. Article beginning on next page discusses changes at this location that were attributed to "El Nino" of 1983.

OIL AND GAS NEWS

Gas injection begins at Mist

Oregon Natural Gas Development began to inject gas into the Bruer Pool on February 11 at the natural gas storage project at Mist Gas Field. During February, a total of 234,125 Mcf of gas was injected, using the injection-withdrawal well IW 32d-10, located in NE¼ sec. 10, T. 6 N., R. 5 W. Plans are to repressurize the gas reservoir to about 25 percent of the original pressure, or some 725 psi, and reduce water influx into the pool. The first withdrawal is planned to occur this fall, depending on market conditions. Injection into the Flora Pool began during March using the injection-withdrawal well IW 33c-3, located in SE¼ sec. 3, T. 6 N., R. 5 W.

NWPA annual symposium scheduled

The Northwest Petroleum Association (NWPA) has scheduled its annual symposium for May 18 and 19 at the Riverhouse Motor Inn, Bend, Oregon. The meeting will focus on the Columbia Basin and Plateau geology and hydrocarbon potential and will include a talk on current geothermal activity in Oregon. A field trip is planned to the Mitchell area, and speakers will discuss tectonics, stratigraphy, geophysics, leasing activity, and other subjects of interest. Information can be obtained from Phil Brogan, (503) 382-0560, or the NWPA, P.O. Box 6679, Portland, OR 97728. □

GSA to hold 1987 Annual Meeting in Arizona

Phoenix, Arizona, will be the site of the 1987 Annual Meeting of the Geological Society of America (GSA) October 26-29. It is the first time that the Society has met in Arizona and thus represents the first official, comprehensive coverage of the geology of Arizona by one of the world's largest earth science meetings. Twenty-seven symposia will address topics from the geology of human origins and cultural evolution to the geology in China. Thirty-four field trips before and after the meeting will explore the southern Colorado Plateau and Basin and Range. There will even be two exciting Colorado River float trips. Subjects of the eight new short courses sponsored by the Society include contaminant hydrogeology, paleoseismology and active tectonics, planetary geology and remote sensing, and site characterization for high-level nuclear waste disposal.

The 200-booth technical geoscience exhibit will include the newest and finest in computer hardware and software, spectroscopes, microanalysis and X-ray diffraction equipment, cameras, maps, publications, and field supplies. GSA will also offer its popular employment service, which is open to both employers and job seekers. For further information, contact Nancy Reed at GSA headquarters, (303) 447-2020. □

South Carolina accepting applications for Geologist and GIT Grandfathers

Geologists and geologists in training seeking registration **without examination** in South Carolina must submit application and fees by June 10, 1987 (postmarked). Application packets are available for $5.00 from South Carolina Board of Registration for Geologists, 1213 Lady Street, Suite 201, Columbia, SC 29201, phone (803) 253-6498. □

New USGS phone number listed

The U.S. Geological Survey, Western Region, Menlo Park, California, has changed to a direct-dial telephone system.

Effective April 1, 1987, the Public Affairs Office, Western Region, will have the following phone number: (415) 329-4000. □

Erosional changes at Alsea Spit, Waldport, Oregon

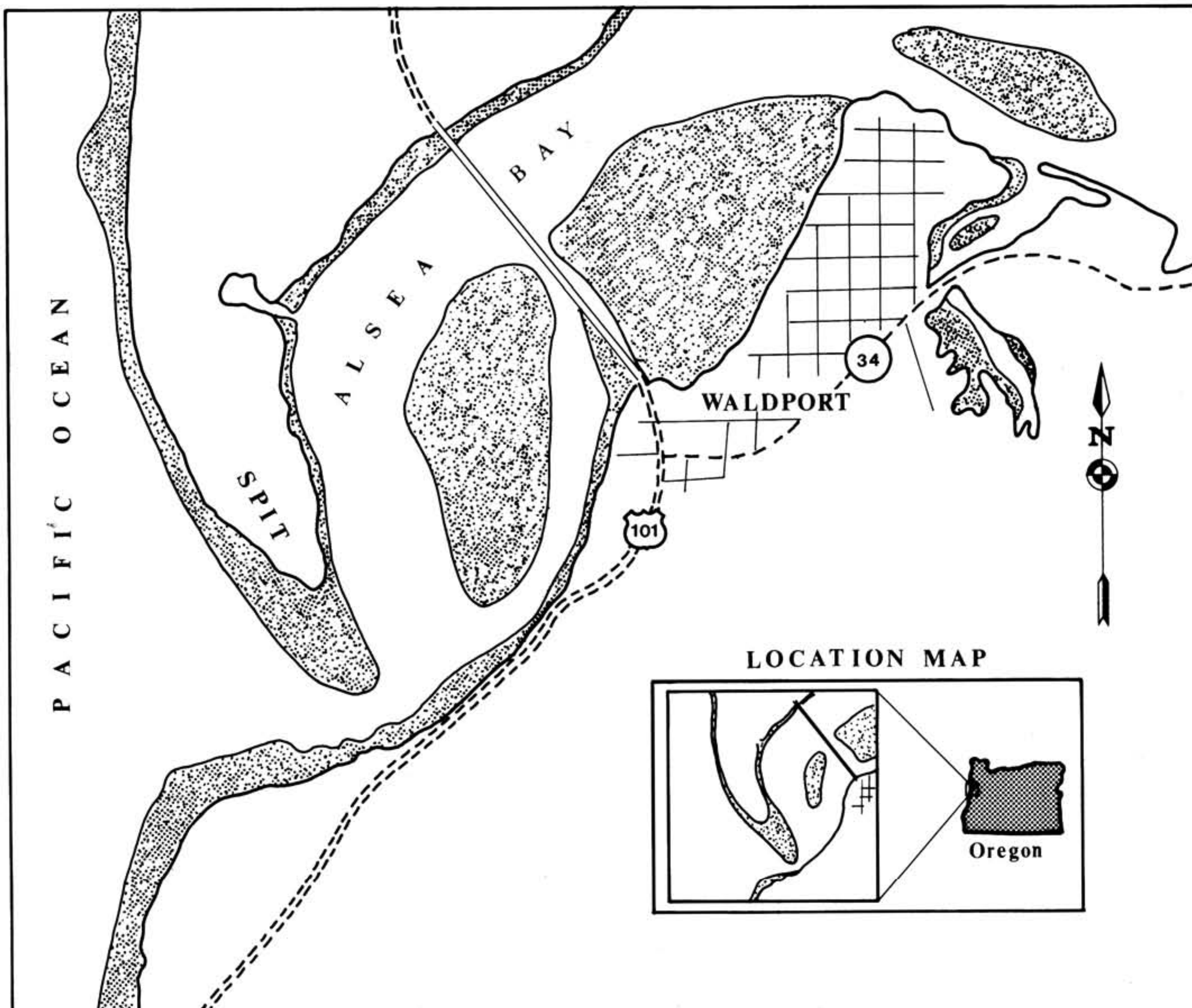
By Philip L. Jackson, Assistant Professor, and Charles L. Rosenfeld, Associate Professor, Department of Geography, Oregon State University, Corvallis, Oregon 97331.

INTRODUCTION

Marine erosion that was attributed to the effects of the 1983 "El Nino" resulted in the loss of the distal tip of Alsea Spit in 1985. Within a five-week period, the inlet to Alsea Bay opened to a width of over 1,900 ft (580 m), quadrupling the previous cross-sectional area of the channel, and subjecting the City of Waldport to increased flooding risk from winter-season high tides and storm events.

In October 1985, a study team was assembled at Oregon State University (OSU) in response to a request from Lincoln County. This resulted in intensive monitoring of marine erosion and flood potential over the subsequent 18 months. As erosion rapidly claimed the distal tip of Alsea Spit and threatened to undermine homes on the perimeter of Bayshore Subdivision, the County Board declared an emergency and appealed to state and federal agencies for technical and financial assistance. Law prohibits the use of state or federal funds for structural mitigation measures outside incorporated areas, so the Governor, acting on the best information available, declared an emergency but could not offer direct financial assistance. It was immediately apparent that the City of Waldport was in jeopardy of increased flood risk, since the spit had previously served as a barrier to direct wave attack and storm surge. With substantially heightened risk to people and property, the focus of the hazard evaluation turned to the city, where some homes are sited at 10 ft above mean sea level* (+10 ft [3 m] MSL), and some commercial buildings on U.S. Highway 101 (Main Street) are at only +12 ft [3.6 m] MSL. An intensive surveying and field monitoring effort was carried out

* *Average elevation of sea surface for all tide stages recorded over a 19-year period.*



Map of Alsea Spit at Waldport, Oregon. Textured areas indicate migratory sand areas under current, shore-normal conditions. Graphics by Doug O'Neil.

to provide data and information that would help to understand the dynamics of the situation and provide the basic findings for proposals seeking federal emergency assistance for protective structures.

A computer model of tidal channel dynamics was used to estimate marine flood potential, and a monitoring effort has kept watch over changing inlet conditions. The rate of spit recovery has been documented, and the information gathered provides a continuous record of the temporal and spatial scale of the erosion episode (Jackson and others, 1986).

By December 1985, the Alsea Bay inlet had widened to its maximum extent. Homes on the spit protected by rock revetments were isolated on peninsulas between unprotected vacant lots.

PROCESSES OF CHANGE

The configuration of Alsea Spit and the inlet to Alsea Bay have remained relatively constant since the first reliable topographic maps of the area were published in 1914. This consistency of form is primarily due to the regularity of seasonal coastal processes that have yielded a zero net littoral drift. The southwest winter-storm cycle erodes old marine terraces and beaches, causing the development of nearshore sandbars and a significant northward transport of sediment by longshore currents. The milder seas of summer produce nearly continuous northwest wave swells that gradually push the sand back onto the beaches with a southerly drift that virtually cancels the effects of winter storms (Schlicker and others, 1973). Under these conditions, the position of Alsea Spit and the configuration of the inlet have varied only seasonally, with the principal tidal flow maintaining a bedrock-confined channel close to the south shore of the bay (RNKR Associates, 1977). Previous reports described Alsea Spit as a prograding spit. Stembridge (1975) observed accretion averaging 10 ft (3 m) per year over several decades. The cover photo provides a selective chronological photo record of changes from 1939 to 1985.

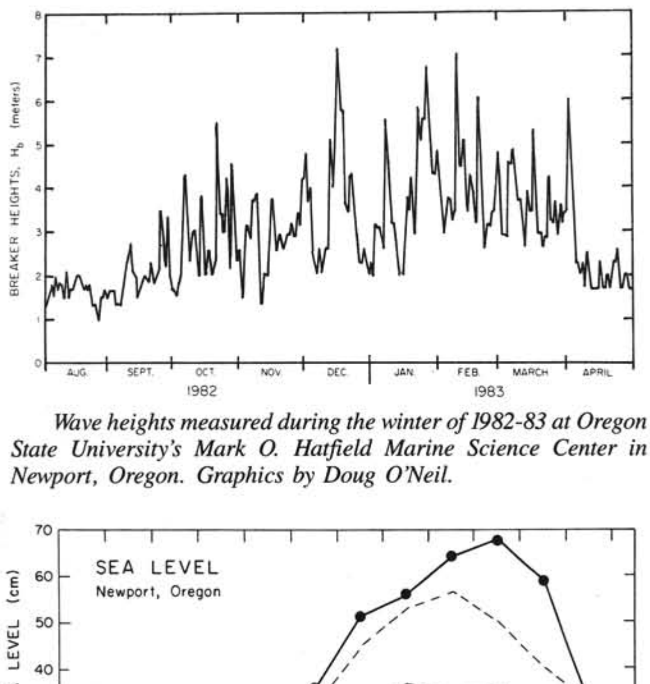
The El Nino-Southern Oscillation (ENSO) event that generally lasted from April 1982 through July 1983 pushed a "bulge" of warm water up along the west coast of the United States, disrupted Pacific Coast weather norms, and resulted in higher than normal sea levels. The magnitude of the weather anomaly was ranked among the most significant of this century. While many elements of the ENSO event immediately contributed to Oregon coastal erosion, some had latent effects as well.

A simultaneous rise in sea level and the increased frequency of high-energy storm wave conditions are known to have contributed directly to severe erosion and property damage during the winter of 1982-83. Breaker heights on the order of 23 ft (7 m) were recorded on the OSU Marine Science Center microseismometer at Newport during three major storm events (see graph of wave heights). These major storms struck the coast at about the same time when sea level was near maximum (see graph showing sea levels) and when annual astronomical tides were strongest. High tides during the December 1982 storm reached 11.0 ft (3.3 m) above mean lower low water** (+11.0 ft [3.3 m] MLLW), 1.9 ft (0.5 m) higher than the predicted level. A January 1983 storm brought a tide level reaching to +12.4 ft (3.8 m) MLLW, 2.8 ft (0.8 m) higher than expected, and a February 1983 storm tide measured 1.4 ft (0.4 m) above that predicted. All these tide events are exceptional for the Oregon coast (Huyer and others, 1983; Komar, 1986).

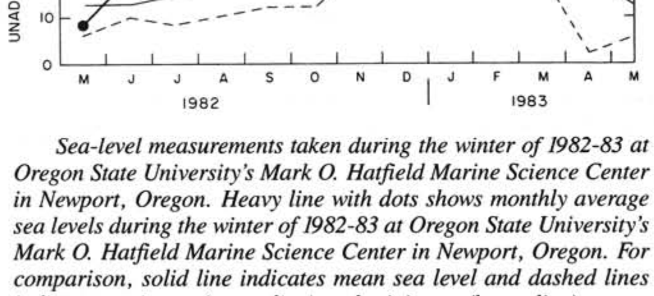
The ENSO effect is triggered by a breakdown of tradewinds in the western Pacific that allows a "bulge" of warm water to move eastward along the equator, until the "bulge" splits at the coast of South America. The northern portion travels along the continental shelf, held along the coast by wave refraction and the Coriolis force. This eventually raises sea levels along the west coasts of Mexico and the United States for periods of up to six months.

The winter storms of 1982-83, accentuated by El Nino, were a nightmare for residents of Alsea Spit. The powerful northward longshore drift, accompanied by sediment from freshly eroded beaches and terrace deposits to the south, produced a massive sandbar along the south shore of the bay mouth. This effectively deflected the discharge from the bay northward, cutting a channel close to shore along the distal tip of the spit. This allowed the big storm

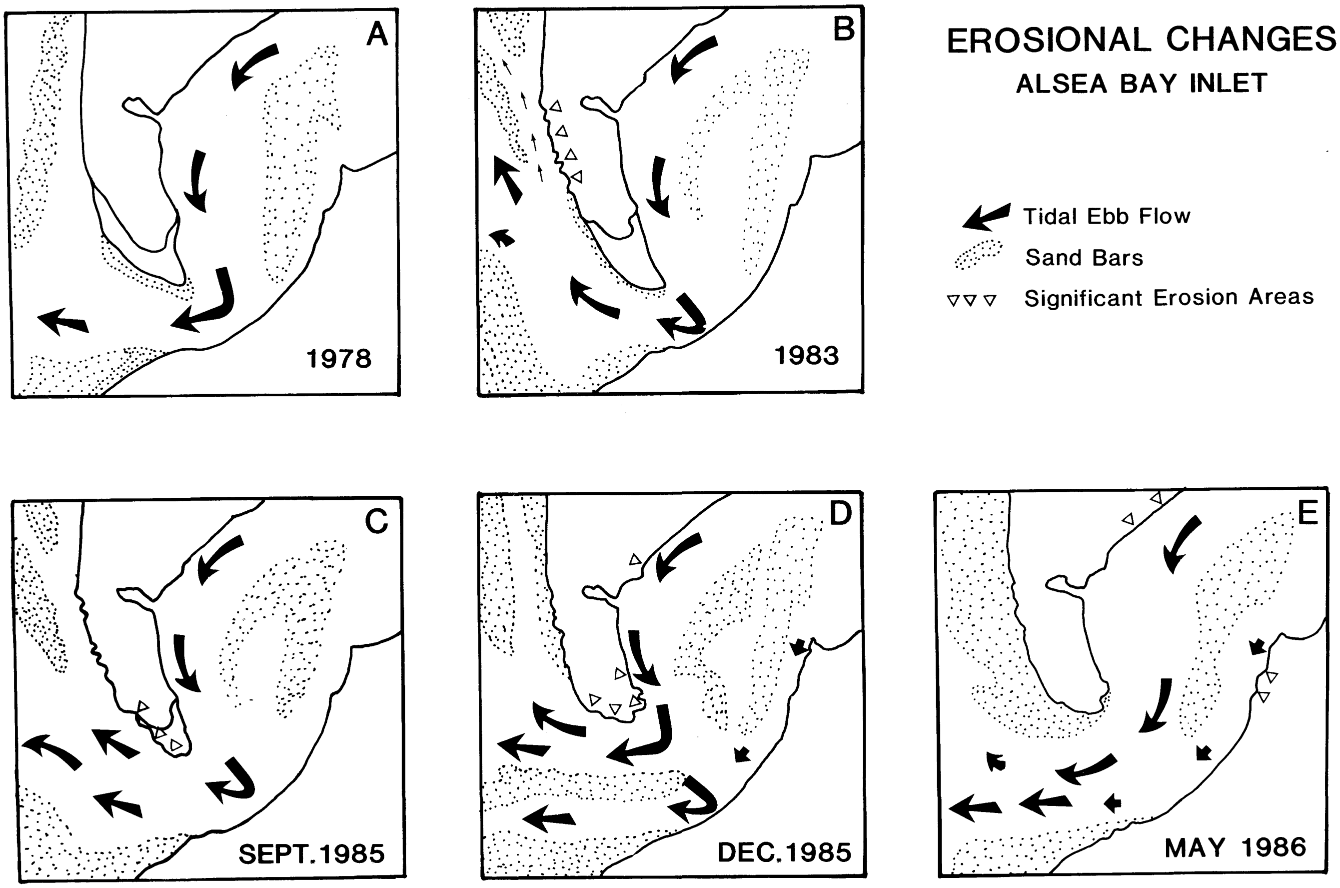
*** Calculated elevation standard derived from average of 19-year recording period. For area discussed here, MLLW = MSL-4.1.*



Wave heights measured during the winter of 1982-83 at Oregon State University's Mark O. Hatfield Marine Science Center in Newport, Oregon. Graphics by Doug O'Neil.



Sea-level measurements taken during the winter of 1982-83 at Oregon State University's Mark O. Hatfield Marine Science Center in Newport, Oregon. Heavy line with dots shows monthly average sea levels during the winter of 1982-83 at Oregon State University's Mark O. Hatfield Marine Science Center in Newport, Oregon. For comparison, solid line indicates mean sea level and dashed lines indicate maximum (upper line) and minimum (lower line) ranges of sea levels over all years on record. Graphics by Doug O'Neil.



Erosional changes at Alsea Spit and Alsea Bay inlet. Graphics by Doug O'Neil.

waves to attack the spit unimpeded by shallow water (see figure showing erosional changes, for a chronology of significant tidal channel changes and erosion areas). The result was catastrophic, as erosion cusps narrowed the spit by over 200 ft (656 m) in places (Erosional Changes Map B). Residents fought back with hastily placed riprap, which was quickly "swallowed up" by high wave energy.

The channel deflection resulted in a steep foredune face all along Alsea Spit that slumped and eroded with each succeeding storm event. Some homeowners placed riprap on the eroding shorefront and succeeded in stabilizing the foredune beneath their structure, but adjacent unprotected lots eroded away, leaving the homes perched — often with oceanfront doors that opened to a 25- to 30-ft (7.6-9 m) drop to the beach, a condition that actually resulted in an injury to a resident! Ultimately, one house was lost, and several remain perilously close to the erosion bluff.

Predominant northwest sea swells in summer 1985 gradually pushed the nearshore sandbar back toward the beach with a gentle southward drift. This activity gradually dismantled the large sandbar deflecting the ebb current of Alsea Bay, but in doing so exposed the southern tip of Alsea Spit to nearly direct wave attack (Erosional Changes Map C). From August to November 1985, the tip was eroded to a narrow taper. The mass of sand moved north by El Nino spread out and choked the narrow but deep channel with more sand than the ebb tide could flush out.

In this situation, tidal action became critical. No longer confined to a narrow but deep (40-ft [12-m]) channel, the peak velocities of the flood and ebb tides cut laterally into the soft spit on the north side of the inlet. Between September and November 1985 (Erosional Changes Map C), the inlet width increased from 400 ft (122 m) to nearly 1,900 ft (580 m). Two distinct channels, each nearly 20 ft (6 m) deep, occupied the flanks of the inlet.

With the onset of the 1985-86 winter-storm season, the harsh reality of the changes became evident. Wave attack on the residential areas at the tip of the spit was brutal. Rocks large enough to form an effective revetment against the waves were unfortunately also heavy enough to sink as a result of hydraulic "pumping" of the sands by those same waves.

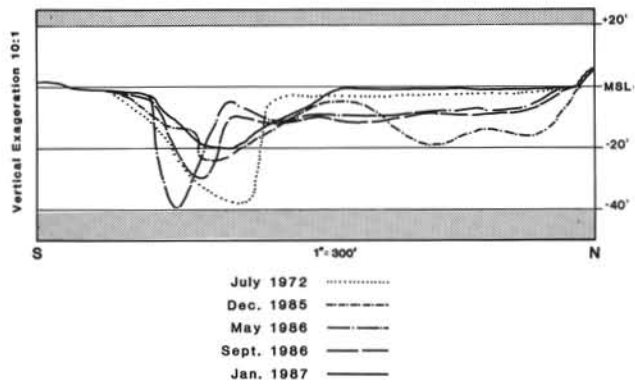
EFFECTS OF CHANGES IN THE TIDAL INLET

The cross-sectional area of the tidal inlet has changed significantly since bathymetry was measured by the OSU Ocean Engineering Department in 1972. In 1972, the cross section of the inlet channel at its narrowest point with a width of 259 ft (79 m) was 5,520 ft^2 (513 m^2), a shape that remained nearly constant until September 1985. By December 12, 1985, the inlet area had increased to 21,789 ft^2 (2,025 m^2), an increase of almost 400 percent. This dramatic change in cross-sectional area was assumed to have the effect of increasing the amount of ocean water entering the bay at high tide. To predict the likely flow characteristics and sea-surface elevations resulting from the changes in inlet area and configuration, the investigators decided to adapt the Tidal Inlet Hydraulics Model to computers at OSU. Scientists of the Coastal Engineering Research Center (CERC) at the U.S. Army Corps of Engineers Waterway Experiment Station at Vicksburg, Mississippi, cooperated in the installation of the model and in the review of the findings (Sorenson, 1978; CERC, 1984). A wide range of ocean-bay configurations were simulated on the basis of 1972 and 1985 field data.

The findings of the model indicate that the peak tidal flux, or water flow through the inlet due to tidal change, increased from a 1972 value of 30,790 ft^3 (872 m^3), per second to 49,600 ft^3 (1,405 m^3), per second in 1985, an increase of over 62 percent. At this rate of flow, the channel volume exceeds the maximum recorded

Changes in Cross-Sectional Area

Alsea Bay Inlet



Date:	July 1972	Dec. 1985	May 1986	Sept. 1986	Jan. 1987
Cross Sectional Area:	513 m²	2025 m²	1527 m²	1591 m²	912 m²

Changes in cross-sectional area of Alsea Bay inlet between 1972 and 1987. Graph shows changes in shape; table presents corresponding measurements of cross-sectional area. Graphics by Doug O'Neil.

discharge of the Alsea River (38,850 ft³ [1,100 m³] per second). The mass transport of water across the outer bar due to wave action or storm surge is also enhanced and tends to raise the sea-surface elevation and increase the flow rate through the inlet. The normal cross-sectional area of the tidal inlet acts as a valve restricting the flow of tidal water into the bay. Under the pre-1985 inlet configuration, the ratio of bay-surface to sea-surface elevation is calculated at 0.71, i.e., a +10-ft (3-m) tide would raise bay-surface elevation to slightly over 7 ft (2 m). This ratio was measured in 1972 and accurately predicted by the tidal inlet model under 1972 conditions. With a large inlet, such as that observed in 1985, the ocean-to-bay ratio is 1.00. Detailed calculations for Alsea Bay indicate that under a range of conditions, each high-tide cycle could result in up to 2.4 ft (0.7 m) higher bay-surface elevations than in 1972—water levels effectively above the height of previously installed riprap and shoreline protection. As long as the ocean-to-bay ratio remains at 1.00, storm surge and wave setup can increase bay elevations in excess of the predicted tidal levels. This means that more water enters and exits the bay at each tidal cycle, and the direct result is increased erosion of the interior of the bay. One focus of erosion has been observed along the Maple Street area in Waldport from the Alsea Bay bridge west to the sea wall (Erosional Changes Map E). Bank retreat in some areas measures over 30 ft (9 m), and in one section, decayed cedar pilings were exposed. The presence of the pilings raises speculation that the eroded area may have been old earthen fill and therefore more easily lost to high water and wave action. Another extensive zone of erosion is found on the north shore from the bay bridge to west of the Bayshore Inn (Erosional Changes Map E). Here a concrete boat ramp was undercut and destroyed by erosion. The shoreline in this area has been cut back by 35-50 ft (10-15 m) into unconsolidated sand and buried log debris. Tidal ebb continues to form erosional cusps in reaches of unprotected shoreline along the bay side of Alsea Spit from the Bayshore Inn to the inlet.

The model of ocean-bay interaction indicates that flood risk to Waldport was significantly increased by the enlarged inlet configuration during the winters of 1985-86 and 1986-87. The West Coast winter-storm period (November-February) happens to coincide with the highest astronomic tides (spring tides) of the year. Our calculations based on winter 1985-86 conditions with an inlet area in excess of 16,000 ft² (1,500 m²), indicate that a 100-year storm event could generate tides and wind-driven waves of sufficient magnitude to cause substantial flooding to the greater portion of Waldport. Under these extreme conditions, ocean swells would carry into the bay, and breaking waves would have greater runup potential, causing especially severe damage to the Maple Street area (Holman, 1986).

Swirling tidal eddies gouge erosional cusps along the tip of Alsea Spit, while homeowners battle the severe loss of property with basalt riprap.

PRESENT STATUS

Bathymetric profiles indicate that sand is presently being redistributed into the inlet area (see figure showing cross-sectional changes). A sandbar is building southward from the distal tip toward the main channel. Submerged at high tides, the bar is exposed at mean sea level for more than 490 ft (150 m) to the south. January 1987 bathymetry shows an inlet cross-sectional area of slightly less than 10,750 ft² (1,000 m²), the smallest inlet area recorded since the 1985 erosion episode began. The calculated ocean-to-bay ratio has also dropped to 0.93, indicating that the present inlet configuration is acting to somewhat restrict tidal flow through the inlet. The inlet bar is subject to hydraulic scour at flood and ebb, but the recent trends indicate a relatively rapid net growth in the bar. A south channel maximum depth of -40 ft (-12 m) MSL was recorded in January 1986, and an observation dive in the channel indicated that the channel was scoured to bed rock. January 1987 bathymetry shows a main channel maximum depth of only -23 ft (-7 m) MSL with a sand bottom. It appears that as long as the south channel remains clogged, the inlet bar will continue to suffer erosion and scour and thus rebuild at a slow rate. However, the presence of sand in the south channel indicates that a net southward migration of sand is taking place within the littoral cell.

Nearly five years after elevated sea levels and heavy storm surf stripped sand from Alsea Spit and transported it northward, the Alsea Bay inlet continues to remain in disequilibrium. Using O'Brien's equations for determining the stability of inlet channels and adjusting them to the empirical data for West Coast bays, the cross-sectional area of Alsea Bay inlet should be stable at between 4,200 and 5,900 ft² (450 and 550 m²) when in equilibrium (O'Brien, 1969). The effects of the severe ENSO event linger far beyond the norm of balanced sand transport due to seasonal reversals of longshore currents. Close monitoring of inlet configuration over 18 months leads us to conclude that the temporal scale of the ENSO event may be on the order of a decade. Research presently under way seeks to link the detailed monitoring of Alsea Bay inlet with contemporary

An older home succumbs to wave erosion along the Waldport bay front. This event occurred during a moderate high tide but without strong wave activity.

findings regarding erosion and transport throughout the Yaquina Head-to-Cape Perpetua littoral cell, with the ultimate objective being a better understanding of transport processes. This is seen as the first step in developing a predictive model of long-term shoreline change for the Oregon coast.

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New geologic maps for northern Deschutes basin released

Three new geologic maps released by the Oregon Department of Geology and Mineral Industries (DOGAMI) describe the structure and geology of the northern Deschutes basin in Jefferson and Wasco Counties.

The three maps cover a total of six adjoining 7½-minute quadrangles, an area that stretches along the Deschutes River from its confluence with the Warm Springs River in the north to Lake Simtustus in the south and includes the southeastern portion of the Warm Springs Indian Reservation.

Prepared by Gary A. Smith, formerly of Oregon State University and now the University of Arizona, the two-color maps (scale 1:24,000) have been published in DOGAMI's Geological Map Series as map GMS-43, *Geologic Map of the Eagle Butte and Gateway quadrangles, Jefferson and Wasco Counties, Oregon;* map GMS-44, *Geologic Map of the Seekseequa Junction and a Portion of the Metolius Bench Quadrangles, Jefferson County, Oregon;* and map GMS-45, *Geologic Map of the Madras West and Madras East Quadrangles, Jefferson County, Oregon.*

The combined maps show, for the first time, the extent of a newly identified rock unit, the Simtustus Formation, which is 12 to 15.5 million years old. Geologist Smith had formally named and described the new formation in a recent issue of *Oregon Geology* (v. 48, no. 6, June 1986). GMS-43, -44, and -45 are also the first detailed geologic maps of those areas that lie within the Warm Springs Indian Reservation.

Together the three maps identify and describe the geologic structure of the area, five units of unconsolidated deposits, and 22 rock units of Tertiary age, the oldest being approximately 35-40 million years old. In the southern portion of the area, on maps GMS-44 and GMS-45, a special symbol also identifies prominent exposures of deposits derived from eruptions of Mount Jefferson. A time rock chart and a geologic cross section complete the information provided on each map sheet.

The new maps, GMS-43, GMS-44, and GMS-45, are now available at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201-5528. The purchase price for each map is $4, and the entire set of three maps may be purchased for $10. Orders under $50 require prepayment. □

Directory of mineral producers in Oregon now available

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released a new compilation of the State's mineral producers.

Directory of Mineral Producers in Oregon has been published as DOGAMI Open-File Report O-87-3. It was derived from a Departmental computer listing of approximately 800 records, originally designed for internal use.

The new directory presents these records in two tables, one arranged by commodity, the other by county. The commodity grouping of Table 1 includes over 30 commodities—from "Abrasives" to "Zeolite"—and lists all known producers by company name, address, and phone and the location of their sites by county and township-range designation. Table 2 lists operators in each county and the commodities they produce.

The new directory, DOGAMI Open-File Report O-87-3, is now available at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201-5528. The purchase price is $5. Orders under $50 require prepayment. □

REVIEWS OF BOOKS—OLD AND NEW

Rediscovered:

by Ralph S. Mason, former State Geologist

Some Little-Known Scenic Pleasure Places in the Cascade Range in Oregon, by Ira A. Williams. Corvallis, Oregon Bureau of Mines and Geology, The Mineral Resources of Oregon, v. 2, no. 1 (May 1916), 114 p. (Available only in or through libraries.)

Here is a book that is a delight to read, is informative, plentifully illustrated, nicely put together — and that failed almost completely in accomplishing its goal "to enter upon a campaign of active and substantial development of her scenic resources." The "her," of course, refers to the State of Oregon. That the project was undertaken seventy years ago is remarkable, that little more has been done since then is even more so.

In 1915, the author, accompanied by a packer, two riding horses, and three pack horses set out from Government Camp on the south side of Mount Hood and rode along the backbone of the Cascade Range southward to Mount Jefferson, and more especially, Jefferson Park, which nestles against its north side. The leisurely two-week trip was designed to promote interest in tourism to some of the State's volcanic attractions. This trip was followed by a second one to the Three Sisters Mountains even farther south in the Cascade Range. The latter trip started out by auto from Eugene and proceeded over increasingly challenging roads up the McKenzie River Valley. The final portion of this trip was made largely on foot, and in some places even on "all fours."

As one reads the accounts of these two trips, a firm impression is formed that even though the scenery was magnificent, only the hardiest traveler would dare to duplicate the adventure. On the road up to the Cascades from Eugene, for instance, mention is made of a half-mile stretch where the auto was able to travel in high gear! On one risky stretch of trail leading to Jefferson Park, the author comments: "A reasonable amount of caution, however, and the exercise of ordinary judgment reduces the element of danger to such a degree that anyone possessing these qualities in just normal quantity need not hesitate to pass over it." One wonders how many "tourists" were still tempted to make the trip after reading that description.

In sharp contrast to much of today's travel, the 1915 journeys were leisurely, with many side trips and stops to examine features of interest and to comment at some length on them. Many of the geologic features encountered are described in simple, nontechnical language. Even the highly technical petrographic procedure of examining thin sections of rock under a petrographic microscope is described as the party stops at an outcrop of what is now known as the Nimrod granite. Nongeologic phenomena such as flowers and forested areas are also described in considerable detail.

Scenic *Pleasure Places* is profusely illustrated with black and white photos, a few of which have been hand-tinted. Unfortunately the state of the art in photography and printing at that time resulted in less than top-quality prints, especially for some of the panoramic views, with distant snow-covered peaks blending invisibly with the sky. Some of the roadside pictures evoke a powerful nostalgia for things long past — the winding dirt road completely enclosed above by towering firs, the author's pony parked squarely in the single, rutted track, serenely aware that no other vehicle would come that way for a long time.

The author has produced an unusually lucid and error-free text, although the reviewer thought for a time that one glaring error had crept in: In several cases, both Bend and Tumalo are placed in Crook County, which actually lies many miles to the east of these two towns. A check in Loy's "Atlas of Oregon," however, reveals that at the time the author was preparing his text Crook County did in fact encompass both towns — and a lot more real estate to boot. Crook County was originally carved out of Wasco County in 1882 and then suffered the indignity of being itself quartered into what is now Jefferson County, Deschutes County, a greatly reduced Crook County, and the southern portion of Wheeler County. Sic transit gloria...

It is patently unfair for a reviewer to re-examine a work seventy years after the author finished with it. However, the author has produced a piece of writing that adroitly tackles a scientific subject and presents it as an adventure that can be enjoyed both vicariously and actively. This has prompted the reviewer to dust off the faded blue cover and take a second look inside.

For the snow-covered peaks are still there and every bit as beautiful as they were in 1915. Even more importantly, the area surrounding the peaks has been protected from development by the establishment of wildernesses. No roads come very close, and just as the author had to do seventy years ago, any hiker today must approach these beauty spots on foot or on horseback. And this is the way it should be. Natural processes are characteristically slow and deliberate. They yield their secrets only to those who will take the time to examine them in a leisurely fashion —just as the author did so long ago.

Just released:

Cataclysms on the Columbia: A Layman's Guide to the Features Produced by the Catastrophic Bretz Floods in the Pacific Northwest, by John Eliot Allen, Marjorie Burns, and Sam C. Sargent Timber Press, 1986, 210 p., hardcover $19.95. Available from local bookstores or the publisher, Timber Press, 9999 SW Wilshire, Portland, OR 97225 (add $3 for shipping and handling).

If you have ever driven along the Columbia River between Portland and The Dalles and noted such features as hanging waterfalls, steep cliffs with rounded hills above, horizontal sediment terraces between dipping beds of basalt, the scoured "scablands" of The Dalles, or large landslides along the Columbia, then you will appreciate John Allen's latest book, which explains the causes of many of these phenomena.

He and coauthors Marjorie Burns and Sam Sargent tell really two stories. One is the account of at least 40 floods that between 12,800 and 15,000 years ago swept from a temporary lake in Montana across the Columbia River drainage to the Pacific—changing thousands of square mile the of Oregon and Washington topography in the process. The other story is that of J Harlan Bretz, the tenaceous geologist who in the face of open hostility from many of his fellow geologists solved the riddle of "geological peculiarities" in eastern Washington by demonstrating that they had been caused by ancient floods, called in this book "the Bretz floods" in his honor.

The Bretz story is a classic example of the way a geologist turns observations of many details, some of which may appear to be unrelated, into a coherent explanation of a natural event. Anyone who has spent a hot summer's day on the Columbia Plateau has to be impressed by Bretz's ability to imagine the immense floods that repeatedly engulfed the area so long ago. The authors clearly understand the magnitude of Bretz's work and the floods he described and are able to convey the excitement and wonder of both in terms the layman can understand.

The accounts of both the Bretz story and the floods make for fascinating reading. Add to that numerous ground and oblique aerial photographs, detailed maps and descriptions of specific places, and self-guided tours of affected areas of Washington and Oregon, and you have a book that will be enjoyed by anyone who is interested in geology of the Pacific Northwest. This is the kind of book you will first read at home and then take out in the field with you, so you can see first hand the evidence of the Bretz floods. □

ABSTRACTS

The Department maintains a collection of theses and dissertations on Oregon geology. From time to time, we print abstracts of new acquisitions that we feel are of general interest to our readers.

AN INVESTIGATION OF FLUID INCLUSIONS AND GEOCHEMISTRY OF ORE FORMATION IN THE CEDAR CREEK BRECCIA PIPE, NORTH SANTIAM MINING DISTRICT, OREGON, by Mark B. Winters (M.S., Western Washington University, 1985)

The Cedar Creek breccia pipe is located in the North Santiam Mining District, Oregon, approximately 50 km east of Salem. It was emplaced in the Sardine Formation, a series of andesitic flows, breccias, tuffs, and small intrusives of middle to late Miocene age.

The breccia pipe was discovered by Amoco Minerals Co. through soil sampling, a ground magnetic survey, and drilling. It is elliptical in plan view with maximum axes of approximately 110 and 145 m and extends vertically downward over 350 m. The contacts between the pipe and the surrounding country rock are sharp and characterized by sheeted fault zones. A quartz diorite intrusive is located directly beneath the pipe. It is porphyritic, weakly mineralized, and exhibits quartz-sericite alteration.

Two overlapping stages of hydrothermal mineralization are recognized. The first involved the alteration of breccia fragments to fine-grained quartz, sericite, chlorite, and carbonates. The second stage resulted in the deposition of quartz, sericite, chlorite, tourmaline, apatite, hematite, chalcopyrite, bornite, molybdenite, tetrahedrite, pyrite, galena, and sphalerite in open spaces. A later stage during which minor carbonate veins formed is also recognized. Siderite and kaolinite were deposited during this late stage.

Four types of fluid inclusions were distinguished and subjected to microthermometric analysis. Type-I inclusions consist of vapor and liquid and homogenized to liquid at temperatures of 150° to 500° C. The salinities of type I inclusions range from 0 to 23 equiv. wt. percent NaCl. Type-II inclusions consist of vapor, liquid, and halite. Homogenization temperatures of type-II inclusions range from 200° to greater than 625° C. Sixty-five type-II inclusions homogenized to liquid by vapor disappearance and have salinities of 31 to 39 equiv. wt. percent NaCl. Three homogenized to liquid by halite disappearance and have salinities of 58 to greater than 65 equiv. wt. percent NaCl. Type-III inclusions consist of vapor, liquid, halite, and sylvite. Twenty-four of 31 type-III inclusions that were analyzed homogenized to liquid by vapor disappearance, the remainder by halite disappearance. Homogenization temperatures of type-III inclusions range from 325° to greater than 625° C and salinities from 45 to 80 equiv. wt. percent NaCl + KCl. Type-IV inclusions consist of vapor, liquid, halite, sylvite, and one or more other solid phases. Two of these solid phases were tentatively identified as gypsum and anhydrite. Homogenization temperatures of type-IV inclusions range from 375° to 525° C. Thirty-two homogenized to liquid by vapor disappearance, 13 by halite disappearance.

Petrologic and fluid inclusion data indicate that three major hydrothermal events occurred. The first event is represented by type-III and -IV inclusions, the second by type-II inclusions, and the last by type-I inclusions.

Fluid inclusion leachates were analyzed by ion chromatograph. Na, K, Li, NH_4, Cl, SO_4, NO_3, and Br were separated. The Na/K and Na/Li ratios determined from the leachate analyses were used to calibrate Na/K and Na/Li geothermometers.

Data from fluid inclusion and petrologic studies were combined with available thermodynamic data to create a model for ore transportation and deposition processes. Copper and iron were carried in solution as CuCl and $FeCl^+$. Ore deposition occured at 250° to 350° C. A decrease in temperature is probably the primary cause of ore deposition, but an increase in pH and decrease in chloride concentration may also be important.

STRATIGRAPHY AND SEDIMENTOLOGY OF THE OLIGOCENE COLESTIN FORMATION, SISKIYOU PASS AREA, SOUTHERN OREGON, by Erick Anthony Bestland (M.S., University of Oregon, 1985)

The Oligocene Colestin Formation, situated at the base of the Western Cascade Group in southern Oregon, consists of nonmarine volcaniclastic and pyroclastic deposits and lava flows. The formation in its type area near the Oregon-California border has a maximum thickness of 1,600 m and is here divided into nine informal members. Each member consists predominantly of one of the following lithologic types: (1) volcaniclastic deposits of andesitic and basaltic composition, (2) rhyolitic pyroclastic and reworked pyroclastic deposits, or (3) basaltic and andesitic lava flows. The formation is largely contained within an east-west trending graben, which was down-faulted contemporaneous with deposition. Three members in the upper part of the Colestin Formation are characterized by distinct sequences of volcaniclastic alluvial-apron deposits. The alluvial aprons developed adjacent to volcanic centers that were situated to the east along the Oligocene Cascade arc.

VOLCANIC STRATIGRAPHY OF THE DESCHUTES FORMATION, GREEN RIDGE TO FLY CREEK, NORTH-CENTRAL OREGON, by Richard M. Conrey (M.S., Oregon State University, 1985)

About 225 lava flows and ash-flow tuffs of the Deschutes Formation (DF) were mapped at Green Ridge. The units fill east-trending paleovalleys which "sky-out" westward and dip east; the eastward dip of the units decreases as they are traced eastward. The source of the units was west of Green Ridge, as evidenced by the increase in the number of ash-flow tuffs and lava flows in the DF from east to west toward Green Ridge and the presence of viscous silicic lavas and lag deposits in ash-flow tuffs on the west flank of Green Ridge. The exposed DF section at Green Ridge is 1,400 ft thick and consists mainly of basaltic andesites with subordinate diktytaxitic basalts, andesites, dacites, aphyric basaltic andesites and andesites rich in Fe and Ti, ash-flow tuffs, and sediments. The upper 400 ft of the section is devoid of ash-flow tuffs and dacites. Nine paleomagnetic polarity intervals, five normal and four reversed, are recognized in the section; tentative correlation of these intervals with the magnetic time scale suggests that the oldest DF unit exposed at green Ridge is 6.5 m.y. old, and the youngest 4.4 m.y. old.

The DF units at the crest and west of Green Ridge are cut by at least five N.- to N. 13° W.-trending, down-to-the-west normal faults in a zone about 5 mi wide. These faults were possibly active as much as 5 m.y. ago; the developing faults may have provided structural pathways for the ascent of the mafic lavas in the upper 400 ft of the section. The faulting that created the Green Ridge escarpment was probably finished by 3 m.y. B.P. and perhaps earlier. The presence of dense, Fe- and Ti-rich lavas throughout the DF section implies that magmas had relatively easy access to the surface during DF time (7.6-4.4 m.y. B.P.), which suggests that the east-west extensional tectonism that culminated in the

(Continued on page 62, ***Abstracts)***

Glimpses of DOGAMI history

As it started operating in mid-1937 under the first director, Earl K. Nixon, the Oregon Department of Geology and Mineral Industries indeed worked up a storm. The first announcement in the first Press Bulletin *issued (see below) was a summary of the projects started immediately. Further witness of the number of plans and accomplishments through 1938 is the fact that during this period twice as many reports were published as on the average in subsequent years—in fact, about as many as DOGAMI usually publishes nowadays . . .*

From *Press Bulletin No. 1* (November 1, 1937)

"Bureau Conducts Economic Investigations. The State Department of Geology and Mineral Industries has caused a number of investigations to be started. Work is proceeding satisfactorily, and reports on progress will be made from time to time.

"A study of the refractory clays of Western Oregon and their geological relationships is in progress. Dr. Hewitt Wilson, Ceramic Engineer of the U.S. Bureau of Mines and Professor of Ceramics at the University of Washington, is in charge of the testing of the clays to determine their economic value and their possibilities of use in future developments in the lower Columbia River area. Ray C. Treasher, Geologist of the Department, is in charge of the geological portion of the work.

"A statewide report of quicksilver is being handled by Mr. C.N. Schuette, Consulting Engineer, who has had much experience in this field. . .

"The effect of placer mining on the Rogue River is being studied by Dr. Henry B. Ward, Ichthyologist, and by Mr. A.M. Swartley, Consulting Mining Engineer of this Department. . .Mr. Swartley will also be in charge of an investigation of the agricultural lime possibilities of the Willamette Valley.

"The occurrence of tungsten minerals in the Wallowa Mountain region has been partially investigated by Mr. W.O. Vanderberg of the Reno station of the U.S. Bureau of Mines, and the survey is being continued by the Department.

"Mr. Raymond Miller, Metallurgist for the U.S. Engineer Department, is preparing a report on the feasibility of electric steel furnace operation in the lower Columbia River area.

"Dr. Warren D. Smith, Head of the Department of Geography, University of Oregon, is preparing a report on the mineral resources of Lane County. The oil possibilities of the Clarno basin are being surveyed by Mr. D.K. Mackay, Mining Geologist of this Department. A state geologic map is in preparation, under the direction of Mr. Ray C. Treasher, assisted by the staff. Mr. A.M. Swartley, aided by the staff, is revising the catalogue of mines."

From the "Progress Report" in *Press Bulletin No. 2* (December 1, 1937)

"Prospecting for chromite in southern Oregon has been rather difficult. The area is covered with a heavy growth of vegetation which tends to conceal the outcrops, and the deposits themselves are usually quite pockety in nature. Dr. F.W. Lee, Geophysicist of the U.S. Survey, has been retained by the State Department of Geology and Mineral Industries to conduct some experiments with geophysical prospecting for chromite in southern Oregon. . .

"The situation in regard to manganese is considerably like that for chromite. The change in economic conditions makes it possible to consider seriously deposits which have not been economically workable in the past and which may now be of considerable importance. Mr. F.W. Libbey, Mining Engineer, is re-investigating the manganese areas in the light of modern market conditions. At present he is located at Medford and is working in the Lake Creek and Evans Creek district. . .

"Mr. Nixon, Director, has been in the field about half the time the past month, engaged in inspecting some dredge properties in eastern Oregon with the point of interesting qualified dredge operators; arranging for and starting the Clarno structural survey; interesting steel people in manganese operations; arranging for continued investigation of the Rogue River muddy-water situation; and making some field study of black sand concentrates and collecting samples for tests to suggest possible future use of this mineral product as a source of iron, titanium, and chrome."

From *Press Bulletin No. 3* (January 8, 1938)

"Activities During First Half Year. During the period from July 1st to December 25th, the Department received and issued somewhat over 5,000 letters covering general correspondence, publicity and publications, grubstakes, assaying and laboratory work, and requests for information. This is an average of thirty-five letters per day for 145 working days, exclusive of State Assay Laboratory correspondence.

"At the Grants Pass State Assay Laboratory, 611 samples were received, and 1,210 quantitative and 120 qualitative determinations were made. At Grants Pass, the assayer is occupied for approximately 55 percent of his time assaying, 25 percent meeting prospectors and answering inquiries, and the remainder writing assay reports and answering mailed inquiries.

"The Baker Assay office received 642 samples, made 1,262 assays, 40 wet determinations, and numerous qualitative tests. Visitors in quest of information numbered more than 500.

"The record shows that the Director has been in the field slightly more than half the time, visiting the more important mining districts and individual mines." □

***(Abstracts** continued from page 61)*

formation of the Green Ridge faults was present throughout deposition of the DF.

The major element chemistry of DF diktytaxitic basalts, basaltic andesites, and andesites appears to change regularly with TiO_2 content, as shown by decreasing CaO/FeO* (FeO* = total Fe expressed as FeO) with increasing TiO_2, and by decreasing Al_2O_3 with increasing TiO_2 at constant MgO content. The basalts and basaltic andesites with the lowest TiO_2 contents also have the lowest alkali contents. These chemical trends appear to be caused by plagioclase, with subordinate olivine fractionation, and are consistent with the fact that plagioclase and olivine are virtually the only phenocryst minerals in the mafic DF rocks. It is likely that the diktytaxitic basalt with the lowest TiO_2 content is a parental magma.

Fractionation may account for the chemical variations within the mafic rock groups considered separately, but the progression from basalt to andesite appears to be the result of mixing of silicic and mafic magmas. The chemistry of the rocks, especially the CaO/Al_2O_3 ratios, is consistent with such mixing, as is the petrography; opaque minerals are very late to crystallize in the basalts and basaltic andesites, and there is increasing evidence for magma mixing in the series basalt through andesite. Such evidence includes multiple plagioclase populations in the same rock, both of which are resorbed, and resorbed pyroxenes and amphiboles.

Three flows of plagioclase megacryst-bearing basaltic andesite occur near the top of the DF section. The plagioclase megacrysts are up to 5 cm in length, commonly contain apatite inclusions, and resemble the plagioclase in anorthosite bodies. Ilmenite megacrysts are also present. The megacrysts and the presence of highly plagioclase-fractionated aphyric lavas rich in Fe and Ti in the DF suggest that anorthosite bodies are present beneath the north-central Oregon Cascade Range.

Two xenoliths of partly melted cordierite-sillimanite-quartz granulite gneiss were found in a DF ash-flow tuff. The xenoliths demonstrate that granulite-grade metamorphism and at least local partial melting of the lower crust took place beneath the north-central Oregon Cascades. □

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